Strategy for Achieving Sub-micron Orbit Stability at the APS

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Systematic Effects Impacting APS Orbit Correction

RF BPM systematic effects

- Timing / trigger stability
- Intensity dependence
- Bunch pattern dependence
- The "rogue" microwave chamber modes
- Electronics thermal drift

X-ray BPM systematic effects

- Stray radiation striking X-bpm blade pickups
- X-bpm blade misalignment
- Electronics thermal drift
- ID Gap-dependent effects

  (e.g. sensitivity, steering)

Extrinsic systematic effects (noise sources)

- Magnet power supply noise / ripple
- RF system high voltage power supply
- Mechanical vibration
- Thermal effects (Tunnel air / water temperature)
- Earth tides
- Insertion device gap changes

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APS Orbit Correction Hardware

1. **Beam Position Monitors**

   - *Broadband BPMs (MpBpms)*

   - *Narrowband BPMs (NbBpms)*

   - *X-ray BPMs*

2. **Corrector Systems**

   - *"Fast" corrector system*

   - *"Slow" corrector system*

3. **Orbit Feedback systems**

   - *"AC" (RTFB) orbit feedback system*

   - *"DC" orbit feedback system*

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Orbit Stability/ Improvement Strategy Summary

Source Point or Correction System	Types of BPMs used	Present Orbit Stability	Orbit Stability Improvement Strategy at APS
BM - Vert	X-Bpm	< 1 micron	Further improvement is not planned
BM - Hor	MpBpm	Few microns	1. Employ "cogging" - in progress
ID - Vert	NbBpm	* 1.1 microns	1. Add more NbBpms hardware - planned 2. Add XBpms in orbit config. - in progress
ID - Hor	NbBpm/ MpBpm	* 1.5 microns	1. Add more NbBpms hardware 2. Add XBpms in orbit config. - in progress 3. Employ "cogging" - in progress
DC Orbit Correction System			Increase DC BW - alleviate global orbit transients due to gap change effects
AC Orbit Correction System			1. Add 2nd Fast corrector - not planned 2. Add NbBpms/Xbpms in configuration

* RMS Motion computed at User sources from 0.01 Hz to 30 Hz

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Cogging Mode - MpBpms

- **What is "Cogging"?**

  The "Cogging" mode sequences MpBpms electronics through all bunches to measure beam position as compared to measure at a fixed bunch (target bunch)

- **This results in reduced systematics such as bunch pattern and intensity dependence effects**

- **This will allow to use more MpBpms in orbit configuration**

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Background Stray Radiation Effects on ID X-Bpms

- **Contaminates insertion device radiation on the Xbpm blades**

- **"Lattice Modification" has reduced stray radiation by a factor of > 20**

- **About 1/2 SR Sectors have been modified**

- **ID Xbpm data, now, used routinely for user reference orbit at a fixed gap**

- **Study of ID X-Bpm data as gap varies in progress**

- **ID X-Bpm Feedforward with gap may be one solution which will allow to include ID X-Bpm in the orbit configuration**

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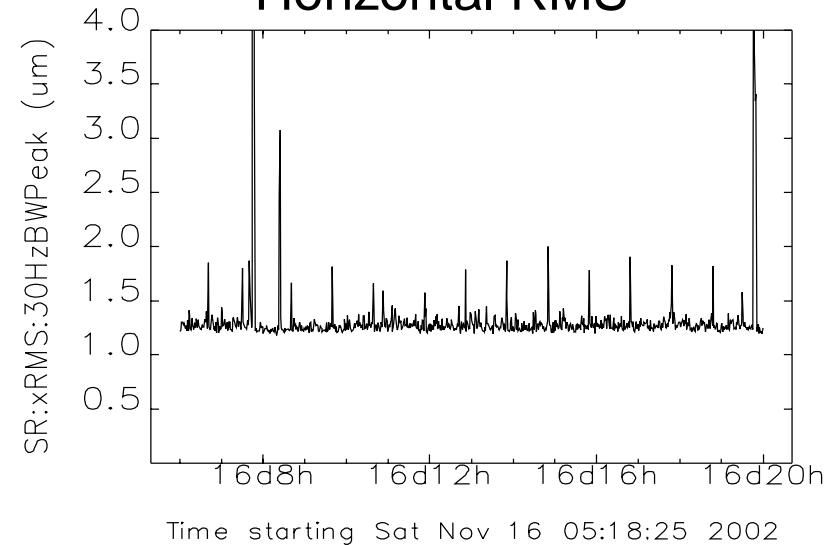# ID Steering Effects with gap changes

- **Causes global orbit distortion, if not corrected**

- **Causes global orbit transients as gap varies**

- **Causes X-ray centroid to vary which is unobservable by rfBpms**

- **May effect blade response due to centroid shape/ and or position changes**

- **Places fundamental limit of several microrad on DC pointing stability as gap varies**

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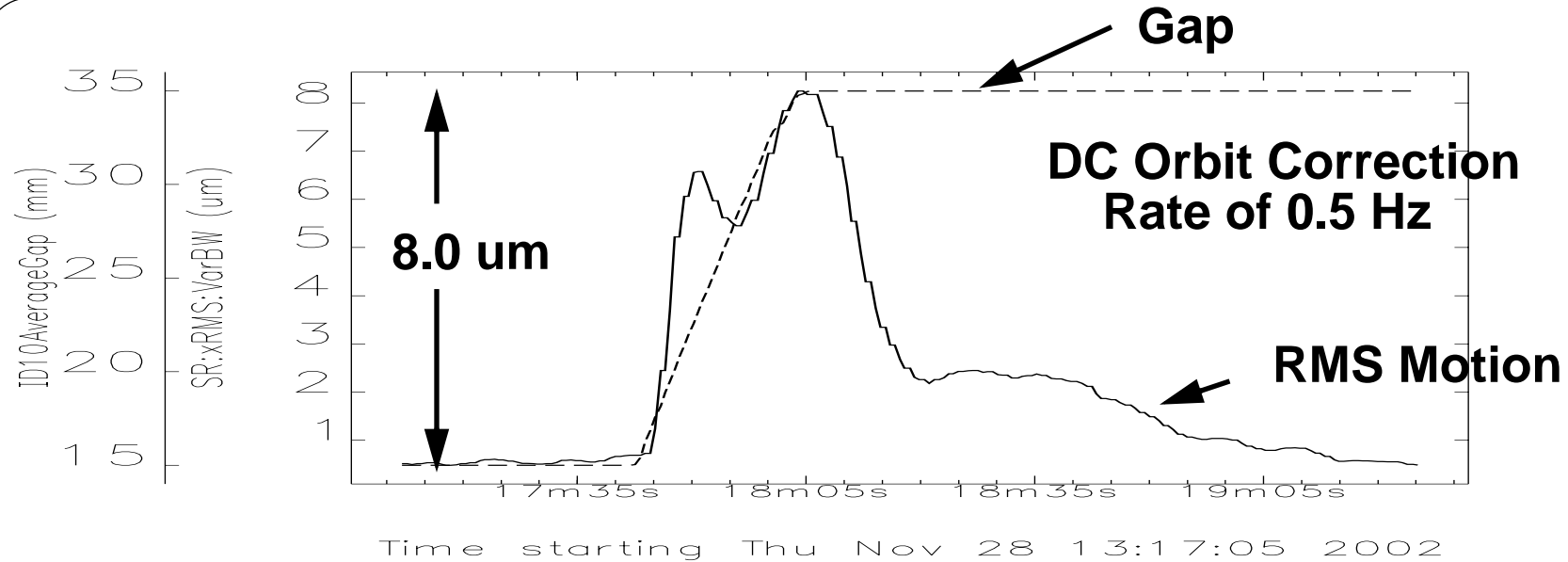# ID Steering Global Transient Effects - 12 Hrs of Operational Run

SR Beam Current

S35DCCT (mA)

Time starting Sat Nov 16 05:18:25 2002

Horizontal RMS

SR:xRMS:30HzBWPeak (um)

Time starting Sat Nov 16 05:18:25 2002

Vertical RMS

SR:yRMS:30HzBWPeak (um)

Time starting Sat Nov 16 05:18:25 2002

A User ID Gap Changes

ID10AverageGap (mm)

Time starting Sat Nov 16 05:19:04 2002

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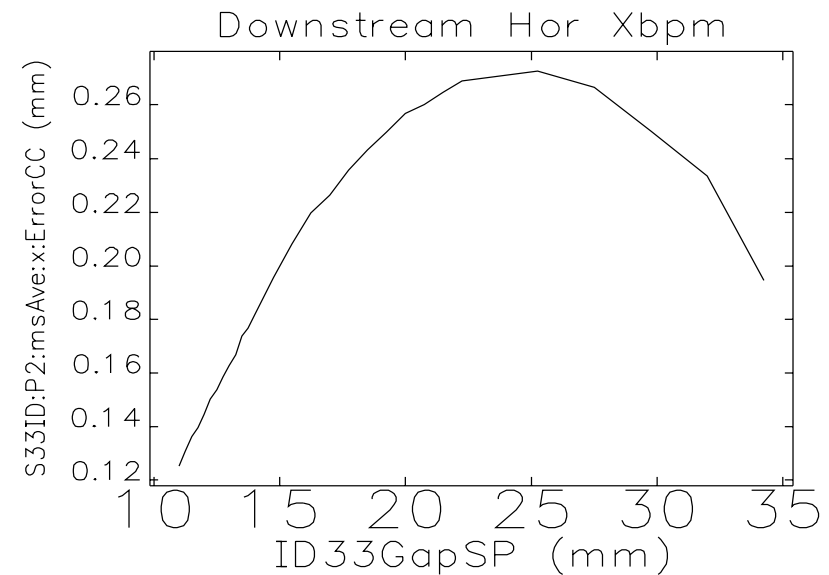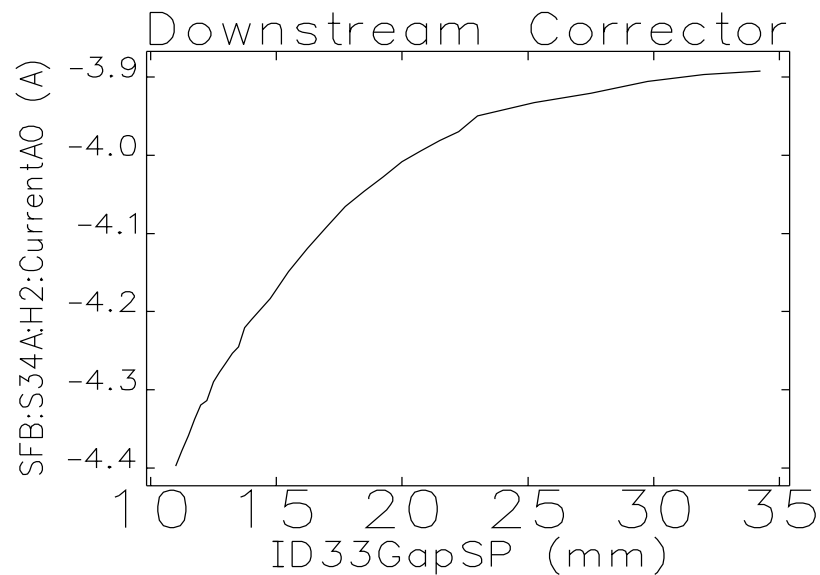**Advanced Photon Source**

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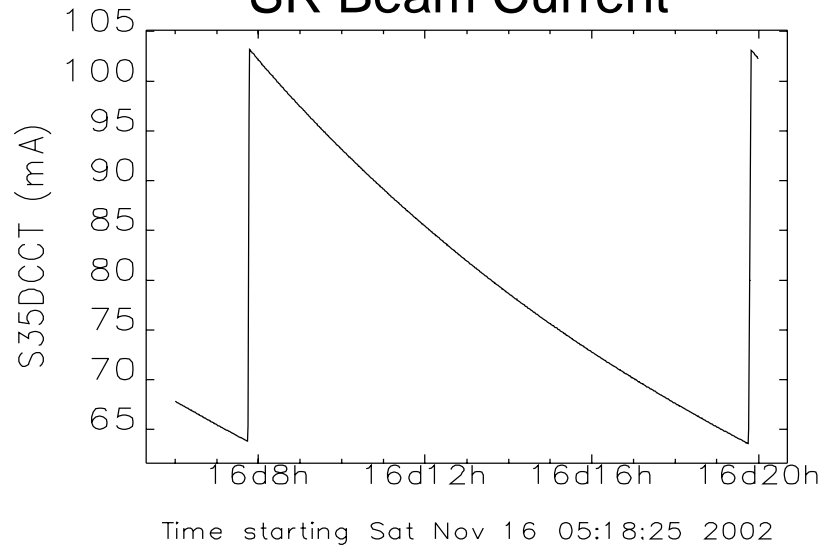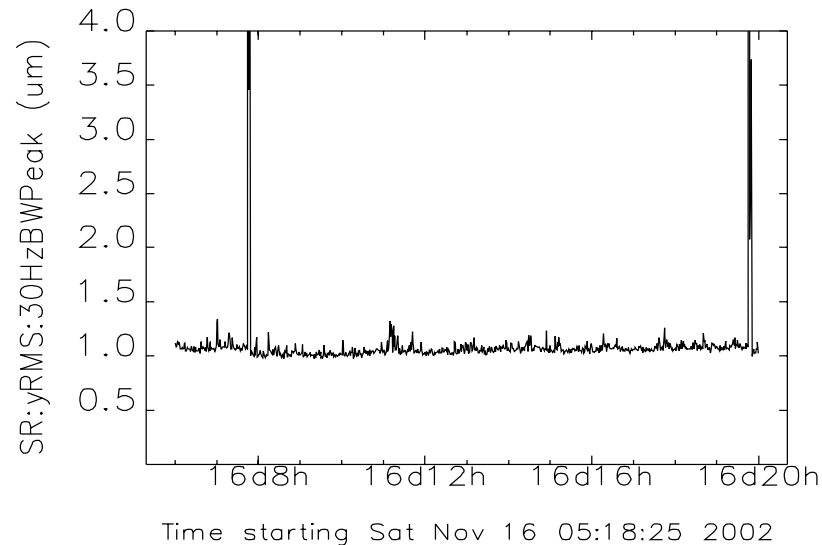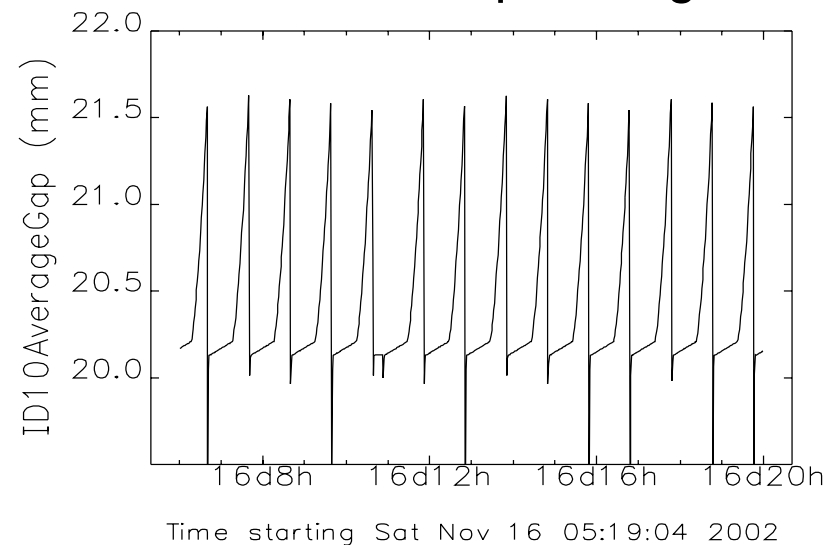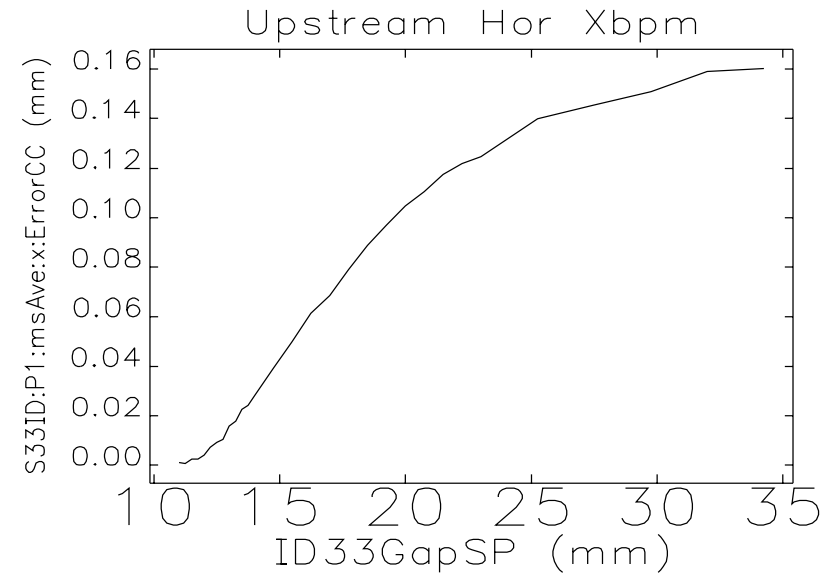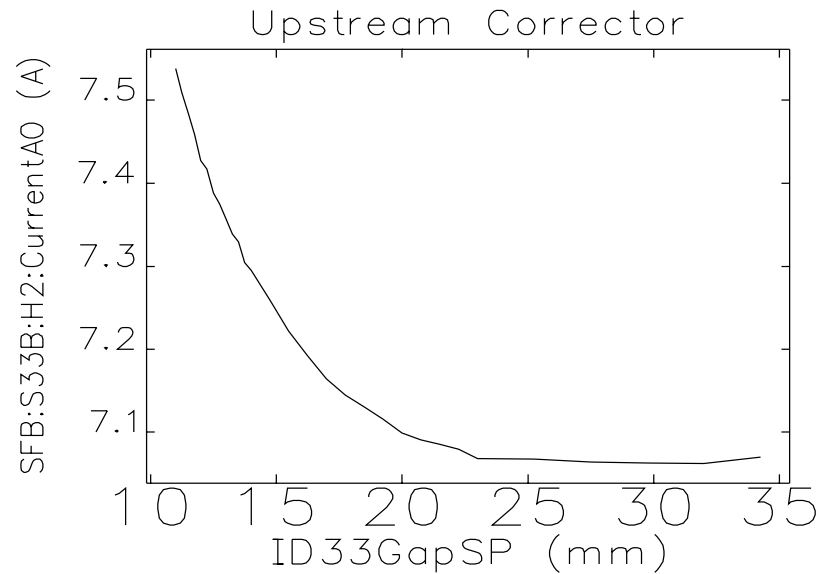
Global Horizontal RMS Motion (0.01 Hz to 1.0 Hz) as ID Gap varies
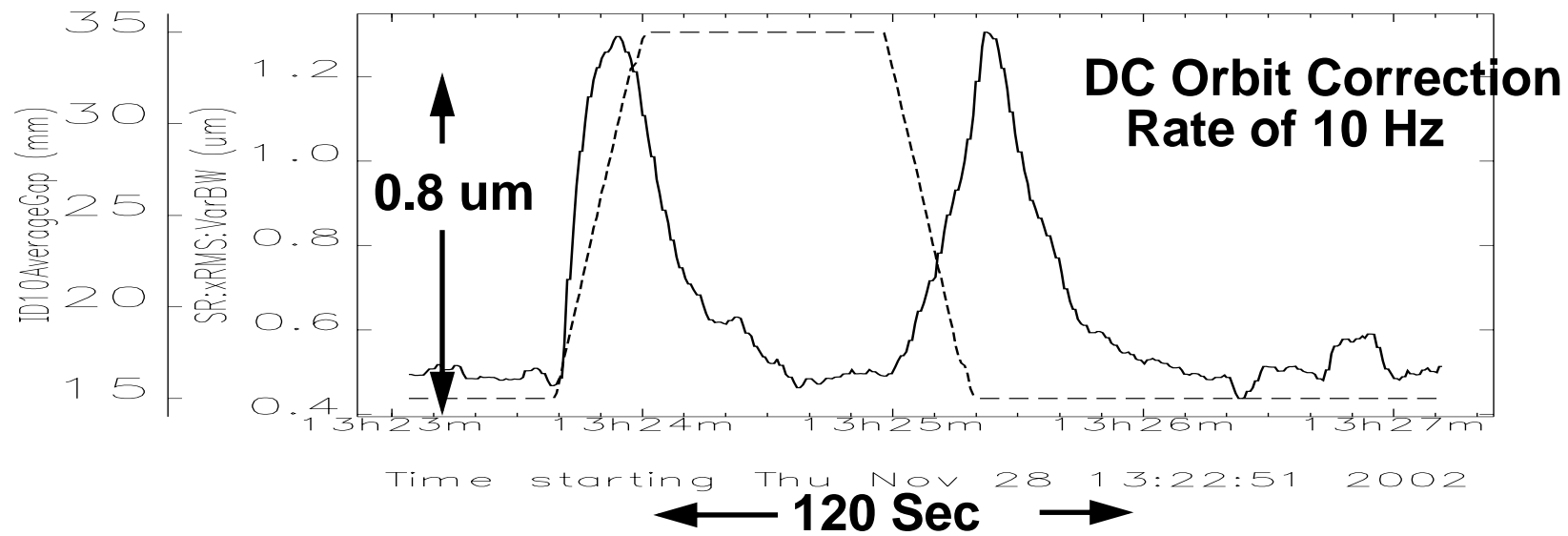
ID Steering Correction and Xbpm Feedforward Data as Gap varies

Increase DC Orbit Feedback BW

- **Strong Case to increase DC orbit Correction Bandwidth**

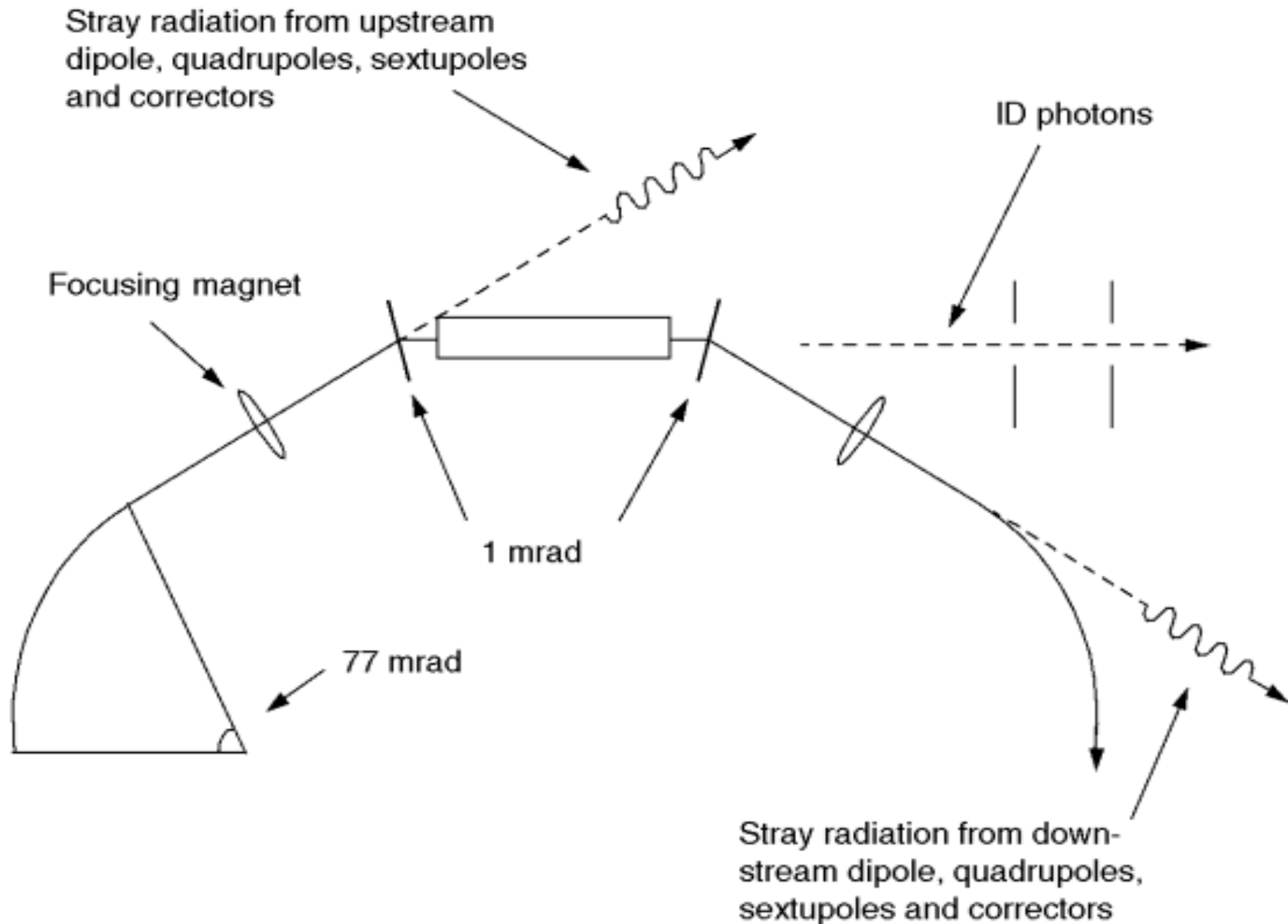 - **Reduces orbit noise by > 3 at a given frequency**

  - **ID Steering effects shows up mostly in freq 0.1 Hz to 1 Hz**

Table 1: Simulation Results

	1 Corr	2 Corr
No correction	1	1
160 BPMs	0.33 (AC)	0.13
320 BPMs	0.3	0.1(DC)

- **New DC orbit feedback system utilizes AC orbit feedback hardware concepts**

- **Added a 22nd VME IOC crate making use of high speed BPMs and cor-rector data available through reflective memory**

- **A 10 Hz DC orbit update rate is in test. Future plan is to increae the update rate to 50 Hz**

- **With 10 Hz DC orbit correction rate, ID steering transient effects has been reduced.**

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Reducing Background Radiation by Lattice modification

Stray radiation from upstream dipole, quadrupoles, sextupoles and correctors

ID photons

Focusing magnet

1 mrad

77 mrad

Stray radiation from downstream dipole, quadrupoles, sextupoles and correctors

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ID 34 and background stray radiations after Lattice Modification

Dipole stray radiations

Upstream   Downstream

12 mm (HOR)

17 mm (HOR)

Vertical = 12 mm

Gap = 21 mm

(Courtesy of D. Shu)

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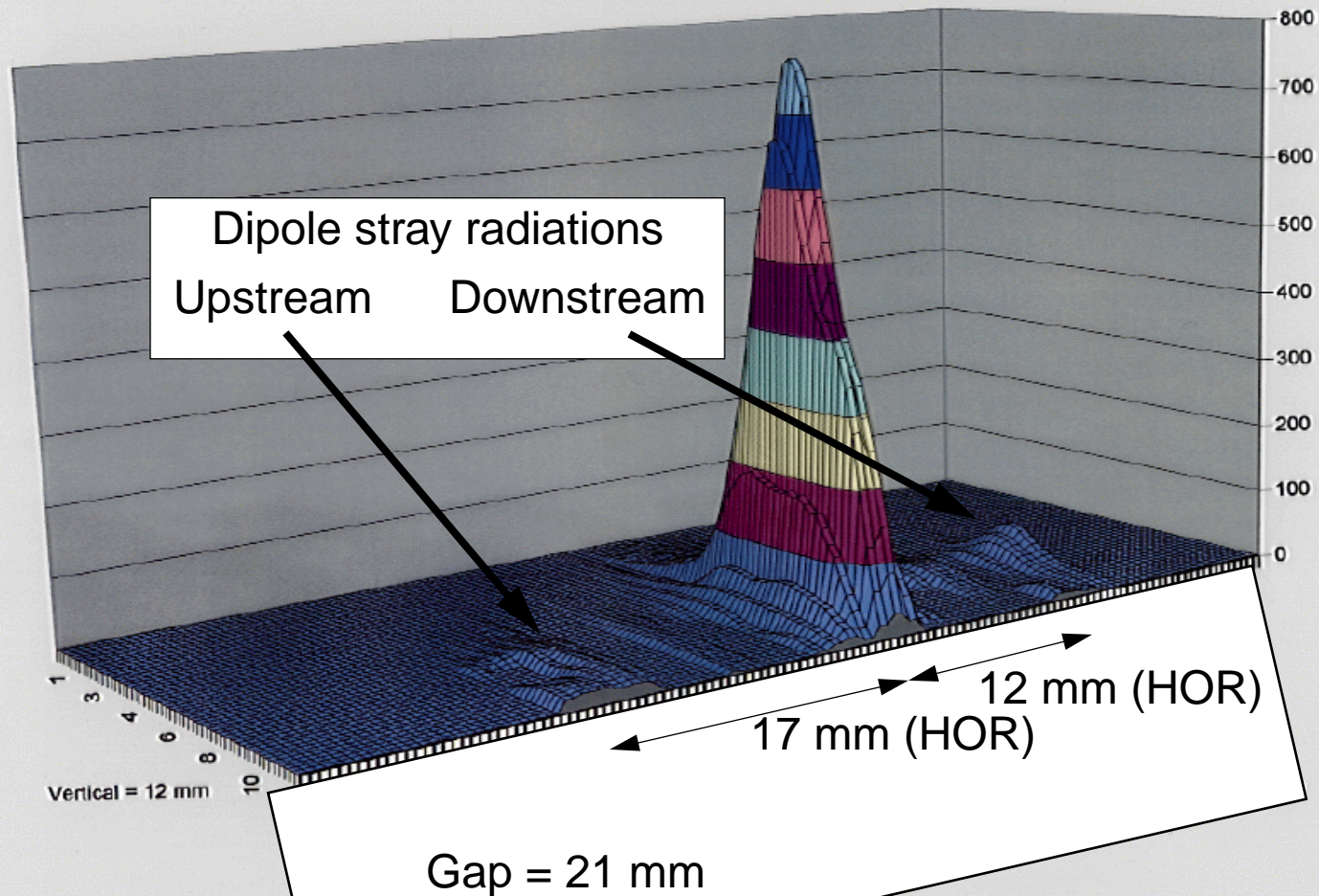
Summary

- **Add more MpBpms in orbit configuration - cogging mode**

- **Add more NbBpms**

- **Add ID X-Bpms in orbit configuration**

- **Increase DC orbit correction bandwidth - reduce ID Steering effects**

- **Add NbBpms and X-Bpms in the AC (rtfb) orbit correction system**

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